Metals & Non-Metals
Extraction of Metals

❖ OCCURENCE OF METALS IN NATURE:

A metal is said to occur native or free when it is found in nature in the metallic state. Those metals which remain unaffected by moisture, oxygen and carbon dioxide of the air can occur native or free.

The reactive metals, i.e., the metals which react with moisture, oxygen, carbon dioxide or other chemical reagents, are not found in nature in free state, but in combined state in the form of compounds.

Occurrence of metals in nature

In free state	In combined state
(gold, platinum, silver, mercury, etc.)	(sodium, calcium, potassium, aluminum, lead, copper, etc).

❖ MINERALS AND ORES

Minerals:

Metal-bearing substances, found in the earths crust, are called minerals. In other words, the solid compounds of metals occurring in nature are called minerals.

Metals can also be classified in terms of their nature and behaviour. For example, metals resembling iron in properties like manganese, chromium, nickel are ferrous metals. They have a similar magnetic behaviour like iron and can be used for preparing **magnets**.

Ores:

The minerals from which metals can be obtained on a commercial scale are called ores. In other words, the minerals from which metals can be extracted profitably are called ores.

For example, Earth's crust contains aluminium in the form of two well-known minerals bauxite
($Al_2O_3 . 2H_2O$) and china clay ($Al_2O_3, 2SiO_2 . 2H_2O$). But the extraction of aluminium is cheaper and easier from bauxite. Hence, ore of aluminium is bauxite.

Thus it can be concluded that –

(i) All ores are minerals, but all minerals are not ores.

(ii) An ore is rich in the amount of the metal. The amount of foreign materials or impurities is low in an ore.

Elements	Ores
Iron	Haematite (Fe_2O_3), Magnetite ($FeO. Fe_2O_3$), Iron pyrites (FeS_2)
Aluminium	Bauxite ($Al_2O_3 . 2H_2O$)
Calcium	Limestone ($CaCO_3$)
Magnesium	Dolomite ($MgCO_3 . CaCO_3$)
Copper	Copper pyrites ($CuFeS_2$)
Mercury	Cinnabar (HgS)
Zinc	Zinc blende (ZnS), Calamine ($ZnCO_3$)
Lead	Lead glance (PbS)
Sodium	Rock salt (NaCl)
Silver	Horn silver (AgCl)

Flux :

A flux is a substance that is added to the furnace charge (roasted or calcined ore and coke) during the process of smelting to remove the nonfusible impurities present in the ore.

Slag :

Flux combines with the nonfusible impurities to convert them into a fusible substance known as slag. Impurities present in metal oxides may be acidic or basic. For acidic impurities, such as SiO_2 or P_2O_5, a basic flux (e.g., CaO) is added to the mixture during smelting. If basic impurities such as MnO are present, silica is added to the flux.

Impurity	Flux	Slag
SiO_2 +	CaO	$\longrightarrow CaSiO_3$
P_2O_5 +	3CaO	$\longrightarrow Ca_3(PO_4)_2$
MnO +	SiO_2	$\longrightarrow MnSiO_3$.

Gangue or Matrix:

The ore mined from the earth's crust contains some unwanted substances or impurities, such as sand, rocky or clay materials. These substances are called **gangue or matrix.**

Classification of Ores / Minerals

(1) Sulphide minerals of metals

Metal	Name of mineral	Formula
1. Copper	Chalocite	Cu_2S
	Chalcopyrite	$CuFeS_2$
	Copper glance	CuS
2. Lead	Galena	PbS
3. Mercury	Cinnabar	HgS
4. Zinc	Zinc blende	ZnS

(2) Oxide minerals of metals

Metal	Name of mineral	Formula
1. Aluminium	Bauxite	$Al_2O_3 \cdot 2H_2O$
2. Copper	Cuprite	Cu_2O
3. Iron	Haematite	Fe_2O_3
	Magnetite	Fe_3O_4
4. Lead	Litharge	PbO
5. Manganese	Pyrolusite	MnO_2
6. Thorium	Monazite	ThO_2
7. Uranium	Pitchblende	U_3O_8
8. Zinc	Zincite	ZnO

(3) Carbonate minerals of metals

Metal	Name of mineral	Formula
1. Calcium	Limestone	$CaCO_3$
2. Copper	Malachite	$CuCO_3 \cdot Cu(OH)_2$
3. Iron	Siderite	$FeCO_3$
4. Lead	Cerussite	$PbCO_3$
5. Magnesium	Magnesite	$MgCO_3$
6. Zinc	Calamine	$ZnCO_3$

(4) Chloride minerals of metals

Metal	Name of mineral	Formula
1. Magnesium	Carnallite	$KCl \cdot MgC_{12} \cdot 6H_2O$
2. Silver	Horn silver	AgCl
3. Sodium	Rock salt (halite)	NaCl

(5) Sulphate ores of Metal

Name	Name of mineral	Formula
1. Barium	Barytes	$BaSO_4$
2. Lead	Anglesite	$PbSO_4$

(6) Silicate ores of metal

Name	Name of mineral	Formula
1. Silicon	Asbestos	$CaMg_3Si_4O_{12}$
2. Silicon	Mica	$KAl_3H_2Si_3O_{12}$

Aluminium is the most abundant metal in the earth's crust.

All minerals of a metal cannot be used for extraction of the metal.

USES OF METALS

Metals are used in the form of pure metals, alloys and in the form of metal compounds.

USE OF PURE METALS

- **Zinc**:
  - (i) It is used to galvanise iron to prevent it from rusting.
  - (ii) It is used in making alloys such as brass and bronze.
- **Iron:** It is used as a catalyst in the manufacture of ammonia by the Haber's Process.
- **Mercury:** It is used in preparing amalgams.
- **Silver and Gold:**
  - (i) Both are used in making ornaments and jewellary.
  - (ii) Both are used in making coins.
- **Chromium and Nickel:**
  - (i) Both these metals are used in electroplating, cycle, motorcycle and other automobile parts.
  - (ii) They are mixed with other metals to prepare useful alloys.
- **Titanium**: Titanium is a light metal. It has a high melting point and boiling point. It is highly resistant to corrosion and has a high tensile strength, even higher than that of steel.

  Due to these properties, it has the following uses :
  - (i) Preparing steel for defence installations (military hardware) marine instruments, aircraft frames. Hence referred to as a **'strategic element'**.
  - (ii) Titanium is used in nuclear reaction.
  - (iii) Titanium is used for making strong structures for construction of buildings.

SOME IMPORTANT METALS COMPOUNDS USED IN DAILY LIFE:

- **Silver Nitrate ($AgNO_3$)** : It is also known as lunar caustic It is colourless, transparent, crystalline solid and soluble in water.

Uses :

(i) As laboratory reagent,

(ii) In preparation of marking inks,

(iii) In photography

(iv) In silvering of mirror,

(v) In manufacturing of other salts of silver.

- **Silver Bromide (AgBr)**: It is pale yellow coloured crystalline compound, insoluble in water.

Uses : In photography

- **Potash Alum** : ($K_2SO_4.\ Al_2(SO_4)_3\ 24H_2O$)

Potash alum is a double salt of aluminum sulphate and potassium sulphate. It is soluble in water. In potash alum crystalline water is found in large amount, so on heating it expands in volume.

Uses: In softening of water.

- **Blue Vitrol or copper sulphate ($CuSO_4.5H_2O$)** :

Copper sulphate is also known as blue vitrol. It is blue coloured, crystalline substance. On heating it gradually releases the crystalline water

$$CuSO_4.5H_2O \xrightarrow{373K} CuSO_4.H_2O \xrightarrow{413K} CuSO_4 \xrightarrow{443K} CuO + SO_2$$

Uses :

(i) In electroplating

(ii) In electric batteries.

(iii) The mixture of $CuSO_4$ and lime is known as bordeaux mixture, it is used as fungicide,

(iv) In dyeing of clothes ,

(v) In preservation of wood